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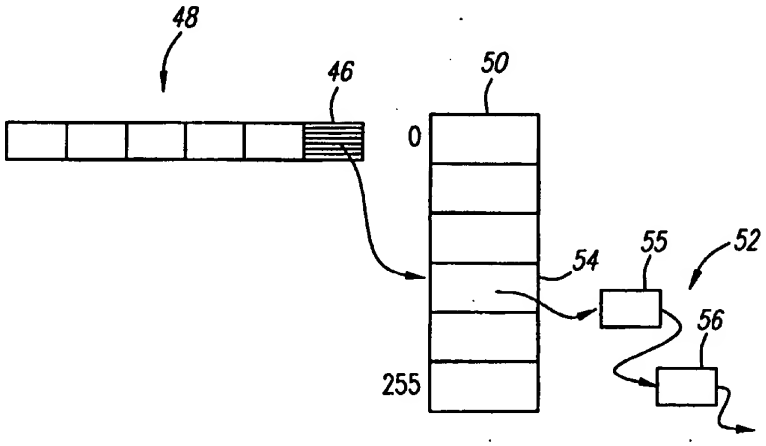

(57) Abstract

A network interface for mapping local ethernet traffic onto an ATM-based broadband access network includes an adaptive MAC-level bridge that employs a fast algorithm for filtering outgoing ethernet packets destined only for local devices on the same ethernet. The network interface reads outgoing packets received on a respective local ethernet segment, using the last byte of the MAC destination address of the packet header to index into a hash table of a linked list containing the first five bytes of respective stored MAC addresses of devices located on the subscriber ethernet segment. If the destination address exists in the linked list, the ethernet packet is dropped, since it belongs to the subscriber LAN segment and is not meant for further upstream transmission over the broadband access network. Since only the last byte of the destination address is used for hashing, a relatively small table of only two-hundred fifty-five entries can be used to index into the remaining five bytes of the respective stored MAC addresses, wherein the linked list keeps track of collisions on addresses linked to the same hash value.

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DESCRIPTION

Network Interface With Adaptive Bridge For Efficient Mapping Of Ethernets Over An ATM-Based Broadband Access Network

Field of the Invention

The present invention pertains to the field of data communication networks and, more particularly, to methods and apparatus for implementing adaptive bridge functionality in a network interface device for providing efficient mapping of one or more local ethernet networks over an ATM-based broadband access network.

Background of the Invention

It has become increasingly desirable to reduce the (overall) required transmission and distribution facilities for providing multiple communication services for residential and business subscribers. For example, in addition to traditional telecommunication and CATV services, it is desirable to further combine the two-way transport of multiple "broadband" digital services over a single, economic distribution network, such as, e.g., a fiber, coaxial, or combined fiber-coaxial distribution network. Further, with the explosion of recent interest in services associated with the "Internet," demand for low cost, high speed two-way digital data transport is at an all time high.

There has been significant development of asynchronous transfer mode ("ATM") networks, which are particularly well-suited for supporting multiple digital data services delivered over a single distribution network. With ATM transmission, data packets, or "cells"

containing information relating to one or more subscriber services are periodically assembled and transmitted from a sending node and received and disassembled at a receiving node, wherein bandwidth utilization is optimized as a function of the statistical service activity. By way of specific examples of ATM-based broadband access networks, a preferred system architecture and data transmission protocol for an ATM-based point-to-multipoint optical network is disclosed and described in U.S. Patent Application Serial No. [not-yet-assigned, Lyon & Lyon Docket No. 220/095], filed April 3, 1997, entitled "Data Transmission Over a Point-to-Multipoint Optical Network." Likewise, a preferred system architecture and data transmission protocol for an ATM-based a point-to-multipoint broadband access network employing a shared coaxial medium is disclosed and described in U.S. Patent Application Serial No. 08/772,088, filed December 19, 1996, entitled "Network Architecture for Broadband Data Communication Over a Shared Medium." Both of these applications are fully incorporated herein by reference.

In order to support such a wide variety of communication signal protocols and service types transmitted over a single subscriber access line, it is necessary to also provide a multi-functional network interface at each respective subscriber premise location, i.e., residence or business. In particular, the network interface must be able to perform the requisite transmission, reception, provisioning (i.e., service parsing and routing) and maintenance needed to achieve a service-independent, transparent gateway between an ATM-based broadband access network and the respective subscriber communication devices. Further, ethernets

connecting two or more devices in a respective business or residence will often carry a significant amount of traffic that is only intended for local use. Thus, the transparent upstream transmission of data packets from this network can be costly in terms of both bandwidth utilization and message security, not to mention the increased cost of the unnecessary transport of the packets throughout the upstream network. As such, it would be desirable to add MAC level bridging functionality to the afore-described subscriber network interface.

In particular, a "bridge" is used to interconnect two or more separate local area network segments (e.g., ethernets). Bridges typically operate by mapping the MAC addresses of the respective end stations residing on each network segment connected to the bridge and allowing only the necessary traffic to pass through to the other segment(s). For example, when a packet is received by the bridge from a network segment, the bridge evaluates the respective destination and source address segments of the packet and, if the segments are the same, the packet is dropped, or "filtered." If the source and destination address segments are different, then the packet is forwarded to the appropriate segment(s). Additionally, bridges may be configured to prevent bad or misaligned packets from spreading between segments by not forwarding them. A more detailed description of LAN bridges and routers is provided in "Interconnections: Bridges and Routers," by Radia Perlman, (1992, Addison-Wesley), which is also fully incorporated herein by reference. Further reference is made to the various LAN bridging standards promulgated by the IEEE 802.1 committee, and, in particular, the 802.1d standard, which was first

published in March, 1991, and which is also fully incorporated herein by reference.

"Learning bridges" make more selective routing decisions by building an internal MAC address table for each connected segment based on the source addresses of respective messages received by the bridge. More recently, multi-port routers and hubs (or LAN switches) have been developed to perform more complex network traffic management functions, such as routing packets between different or multiple LAN types, or based on multiple "virtual" LAN designations. A basic property of learning bridges is that some type of "spanning algorithm" must be employed to prevent never-ending loop backs of data between different bridges; (hence the term "tree," which has no loops). A detailed description of the spanning tree algorithm approach is set forth in the Perlman text.

However, the spanning tree algorithm is complex to implement, can impose significant (i.e., expensive) memory and processor requirements, and does not necessarily provide for good security. As a result, the conventional spanning tree approach is not well-suited for the afore-described network interface application.

Thus, it would be desirable to provide a network interface device having bridging functionality for mapping one or more local area networks, such as ethernets, over an ATM-based broadband access network. Such bridging functionality will preferably provide strict message filtering and security, with relatively low memory and processor requirements.

Summary of the Invention

The present invention provides an improved network interface for mapping local ethernet traffic onto an ATM-based broadband access network, wherein the interface includes an adaptive MAC-level bridge that employs a fast algorithm for filtering outgoing packets destined only for local devices on the same ethernet segment.

In a preferred embodiment, respective subscriber residences and business locations are each equipped with a network interface that provides access to an ATM-based broadband access network. In particular, the network interface includes an ethernet service module that connects one or more MAC devices in the respective residence or business location (e.g., personal computers, printers, fax machines, etc.) as a respective local area network segment.

In accordance with a general aspect of the invention, the ethernet service module reads every outgoing packet received on the respective ethernet segment, first checking the ethernet CRC data then, if the packet data is not corrupted or otherwise misaligned, using the last byte of the MAC destination address of the packet header to index a hash table of a linked list containing the first five bytes of the stored MAC addresses of devices located on the ethernet segment. If the destination address exists in the linked list, the ethernet packet is dropped, since it belongs to the subscriber LAN segment and is not meant for further upstream transmission.

In particular, since only the last byte of the destination address is used for hashing, a relatively small hash table of two-hundred fifty-five entries can be used to index into the remaining five bytes of the

respective stored MAC addresses, wherein a linked list keeps track of collisions on the hash value (i.e., whereby a separate "linked" entry is created for each MAC address having the same common last byte.

In accordance with a further aspect of the invention, regardless of whether the destination address is a match with a stored address, the ethernet service module also checks the source address of the outgoing respective packets by using the same algorithm. In particular, if an address does not already exist in the linked list, it is added. In this manner, the ethernet service module keeps growing its internal database corresponding to the presence and activities of devices on the subscriber ethernet segment.

In accordance with a still further aspect of the invention, a variable timer is employed to track of the "shelf life" of stored MAC addresses, and to ensure that only recently active addresses are stored. In a preferred embodiment, a timer tick is set at a regular interval for traversing the linked list, decrementing the remaining time each of the respective stored MAC addresses has left and, at the same time, deleting those addresses whose life time has expired. Conversely, each time a stored MAC address shows up in the source address field, its "shelf life" allotment is fully reset to a new maximum value.

In accordance with a still further aspect of the invention, the network interface can also be implemented as a protocol interface, in addition to a packet filter. To this end, in a preferred embodiment, ethernet packets that are to be forwarded over the ATM-based network are given respective LLC and AAL-5 layer headers (and new CRC data) for upstream ATM cell transport.

Other and further objects, features, aspects, and advantages of the present invention will become better understood with the following detailed description of the accompanying drawings.

Brief Description of the Drawings

The drawings illustrate both the design and utility of preferred embodiments of the present invention, in which:

FIG. **1** is a functional diagram of an exemplary ATM-based broadband access network that maps a plurality of subscriber residences and business locations over a wide area network ("WAN");

FIG. **2** illustrates a preferred filtering process of outgoing packets from a respective subscriber ethernet LAN segment in the network of FIG. **1**;

FIG. **3** illustrates a preferred process for updating a linked list of stored MAC addresses used in the filtering process illustrated FIG. **2**; and

FIG. **4** illustrates a preferred protocol adaptation process for converting ethernet packets to be forwarded over the broadband access network of FIG. **1** into ATM cell format.

Detailed Description of the Preferred Embodiments

Referring to FIG. **1**, an exemplary ATM-based broadband access network 20 includes an ATM compatible switch 26, which transmits and receives multi-service type ATM cells to and from a plurality subscriber residences 21 and business locations 22, respectively. The ATM switch 26 also transmits and receives ATM cells over a wide area network ("WAN") 24, such as, e.g., a public switched telephone network, a private point-to-

point or point-to-multipoint network, or some combination thereof.

In accordance with a first aspect of the invention, the respective subscriber residences 21 and business locations 22 are each equipped with a network interface facility ("NT") 28. In particular, the NT 28 supports the two-way transport of multiple communication services via RF carrier modulated ATM cells that are transmitted between the switch 26 and respective NT 28 over a hybrid-fiber-coaxial ("HFC") distribution network 40, wherein a respective coaxial feeder cable 38 connects each NT 28 to the HFC network 40. As will be apparent to those skilled in the art, the HFC distribution network 40 may take several alternate physical forms. By way of example, "downstream" ATM cell traffic transmitted from the switch 26 to one or more NTs 28 may initially be multiplexed for transport over a shared high speed optical fiber (not shown), then de-multiplexed for local distribution over a shared coaxial cable (also not shown). In alternate preferred embodiments, a pure optical or coaxial network may be equally employed.

An exemplary preferred NT 28 is shown and described in U.S. Patent Application Serial No. 08/608,436, filed February 28, 1996, entitled, "Subscriber Network Interface And Method," which is also fully incorporated herein by reference. In accordance with that disclosure, ATM cell-mux circuitry (not shown) in the respective NTs 28 provide for de-multiplexing and routing of incoming (i.e., downstream) ATM cells, and for collecting and multiplexing of outgoing (i.e., "upstream") ATM cells, respectively, wherein the incoming and outgoing ATM cells are routed to and from a plurality of "ATM" subscriber service modules (also not shown) within the NT 28.

The respective subscriber service modules each support individual services, including (at least) telecommunications 30 (e.g., POTS and/or ISDN), set-top telemetry 32 (e.g., for CATV video-on-demand), CEBus network 34 (e.g., for connecting utility managed appliances) and ethernet 36. In particular, an ethernet service module 29 in each NT 28 connects one or more MAC devices (e.g., personal computers, printers, fax machines, etc.) in the respective residence 21 or business location 22 as a respective local area network ("LAN") segment (36).

Each service module "disassembles" the respective incoming cells routed to it by the ATM cell-mux circuitry, adapting the data contained therein into an appropriate service protocol for delivery through a subscriber-side I/O port (not shown) associated with the respective service module. The protocol conversion may include, for example, circuit emulation for providing a synchronous digital data stream, depending on the respective service.

Conversely, information in upstream signals received through a subscriber-side I/O port is assembled into sequential cells by the respective service module and delivered to the ATM cell-mux circuitry. In this manner, the ATM transmission of combined services over the network 20 side is advantageously transparent at the subscriber-side (21/22) I/O ports of the respective NT 28.

As described in greater detail below, the destination MAC address of packets received by an NT 28 over a respective ethernet segment 36 is analyzed by the ethernet service module 29 in the NT 28 to determine if the packet is destined for another device on the

respective local LAN segment 36, or is destined for a remote device, such as, e.g., a remote ethernet LAN segment 42 or 44 connected to the WAN 24. In particular, in accordance with standard MAC ethernet protocols, each ethernet data packet includes a header field that contains both source and destination MAC addresses -- i.e., a unique six byte MAC ("media access control") address assigned by the manufacturer of the respective device --, wherein the source and destination MAC addresses are used to indicate the respective transmitting and intended destination devices of the packet.

Referring to FIG. **2**, in accordance with a further aspect of the invention, the ethernet service module 29 reads every outgoing packet received on the respective ethernet segment 36, first checking the appended ethernet CRC data (shown in FIG. **4** with reference number 64) to insure integrity of the packet. If the packet is not corrupted or otherwise misaligned, the ethernet module 29 then uses the last byte 46 of the MAC destination address 48 of the packet header to index into a hash table 50 with a linked list 52 containing the remaining five bytes of any devices located on the subscriber side ethernet LAN segment 36 whose respective MAC addresses are presently stored in the hash table/linked list 50/52. Since only the last byte 46 of the respective destination MAC address is used for the look-up, a relatively small hash table 50 of two-hundred fifty-five entries (i.e., 2^8 -1) is used to index into the remaining five bytes of the respective stored MAC addresses.

In particular, a pointer leads from the associated value 54 in the hash table 50 of the last data byte 46 of the respective destination address to a first linked

memory space 55 corresponding to that value. If there are no stored addresses in the first linked memory space 55, there are no further pointers (i.e., or they point to "null") and the packet is forwarded. If there is an address stored in the first space 55 -- i.e., representing the first five bytes of a corresponding respective local segment MAC address, it is compared to the first five bytes of the present destination address 48 and, if there is a match, the packet is dropped.

If there is not a match, a further pointer will link to a second memory space 56. Again, if there is no address stored in the second memory space 56, then there are no further pointers (or they point to null) and the packet is forwarded. If there is a further address stored (i.e., representing the first five bytes of the MAC address of a second device having the same common last MAC address byte as the stored address in the first memory space 55), a comparison will again be made. This process will continue until either a matched address causes the packet to be dropped, or there are no further stored addresses linked to the respective value 54 of the last byte 46, and the packet is forwarded. Thus, the probability of quickly searching and resolving whether the destination MAC address corresponds to a resident device on the respective subscriber ethernet segment 36 is high.

In other words, each index value of the hash table 50 has an associated linked list 52 containing at any time "n" stored addresses, where n is some integer value from zero up to the number of devices on the local ethernet segment 36.

Regardless of whether the destination address search resulted in a match, the ethernet service module 29 then

checks the source address of the respective packet using the same algorithm. If it does not already exist in the linked list 52, it is added. In this manner, the ethernet service module 29 keeps growing its internal database corresponding to the presence and activities of devices on the subscriber ethernet segment 36.

Referring to FIG. **3**, a variable timer tick 58 is employed to track of the longevity (i.e., "shelf life") of MAC addresses stored in the linked list 52, and to ensure that only recently active addresses are stored. In particular, each time a MAC address shows up in a source address field, its "shelf life" allotment is fully reset to a selected maximum value (i.e., a maximum number of "ticks"). The timer tick 58 is set at a regular interval for traversing the linked list 52 (indicated in FIG. **3** by line 60), decrementing the remaining time ticks each of the respective stored MAC addresses has left and, at the same time, deleting those addresses whose life time has expired.

In a presently preferred embodiment, the shelf life of a stored address is preferably no more than two days, with the timer tick interval 58 selected within a range of anywhere from one second to an hour. As will be appreciated by those skilled in the art, that an advantage of the present invention is that memory space in the linked list 52 is thus only used on an "as needed" basis, i.e., when a further linked address is made to a common last byte.

Referring to FIG. **4**, if a respective ethernet packet 62 is not dropped due to corrupt data, or based on a matching destination MAC address in the linked list 52, then a logical link control header ("LLC") is added by the ethernet service module 29 to the front of the

packet, i.e., with the ethernet CRC data 64 portion of the packet stripped off for evaluation by the ethernet service module 29. The packet 62 is then adapted for ATM transmission by adding an AAL-5 layer header, along with new appended CRC data 70 appended, and the newly formed ATM cell 72 is then inserted into the upstream ATM cell transmission stream from the respective NT 28.

As will be apparent to those skilled in the art, incoming (i.e., downstream) packets are handled much in the same way as the outgoing packets 62, albeit in the reverse order -- i.e., the AAL-5 and LLC headers are removed and ethernet CRC-32 data is appended to the packet before it is forwarded onto the respective ethernet segment 36.

Thus, embodiments and applications of a preferred network interface including an adaptive bridge for filtering out local traffic from that destined for remote ethernets located over an ATM-based broadband access network have been shown and described. As would be apparent to those skilled in the art, many modifications and applications are possible without departing from the inventive concepts herein.

By way of non-limiting examples, the afore-described fast algorithm filtering techniques could be equally employed to filter incoming traffic as well as outgoing traffic. Also, the teachings of the invention may be employed to any number of address formats, i.e., in addition to the disclosed six byte MAC address format. Further, while the disclosed preferred embodiment employs the last byte of the MAC address to index the hash table and associated linked-lists, other selected portions of the address field (e.g., the first byte, or the fourth byte, etc.) could be equally employed for use as an index

value to a remaining portion of an address, as taught by the present invention. Still further, the advantageous fast filtering algorithm taught by the present invention may be employed to selectively identify and filter messages based on any number of identifying factors, e.g., on a matching virtual LAN designation.

Further still, while the above-described preferred embodiment of the invention is implemented as part of a network interface (i.e., NT 28) between a local ethernet segment and an ATM-based wide area network, as will be apparent to those skilled in the art, the advantageous fast packet filtering algorithm taught by the present invention may be implemented in any of a number of bridge devices, and between any number of like or different LAN segment types. Still further, while the respective network interface (NT) devices are shown and described in context of supporting a single ethernet service module, it is well-within the skill in the art to implement a network interface that selectively forwards messages from multiple ethernets to onto one or more ATM-based wide area networks, e.g., with separate adaptive bridge tables for each ethernet segment.

Thus, the scope of the disclosed inventions is not to be restricted except in the spirit of the appended claims.

Claims

1. A method for selectively forwarding messages from a first network to a second network, each message including a destination address, comprising the steps of:

selecting a first value in a table of values based on a first portion of the destination address, each table value having an associated linked list of an integer number of stored entries; and

comparing the remaining portion of the destination address to the stored entries, if any, in the linked list associated with the selected first value.

2. The method of claim 1, wherein the destination address is a six byte MAC address and the first portion used for selecting the respective first table value is the last byte of the respective destination address.

3. The method of claim 1, comprising the further step of:

filtering any message whose remaining destination address portion matches a stored entry in a respective linked list.

4. The method of claim 1, comprising the further step of:

forwarding only those messages whose remaining destination address portion does not match a stored entry in a respective linked list.

5. The method of claim 4, comprising the further step of:

encapsulating each message to be forwarded into an ATM cell transmission format.

6. The method of claim 1, each message further including a source address, comprising the further steps of:

selecting a second value in the table based on a first portion of the source address;

comparing the remaining portion of the source address to the stored entries, if any, in the linked list associated with the selected second value; and

storing the remaining portion of the source address in the respective linked list if there is no matching entry.

7. The method of claim 6, comprising the further steps of:

monitoring the time period each source address portion is stored in a respective linked list; and

deleting a source address portion from the respective list if an allotted time period has elapsed and no subsequent destination address portion match has occurred.

8. The method of claim 7, comprising the further step of:

renewing the allotted time period that a source address portion is stored in the respective list each time a destination address portion match occurs.

9. The method of claim 1, wherein the first network is an ethernet and the second network is an ATM-based wide area network.

10. A method for selectively forwarding messages from a first network to a second network, each message including a destination address and a source address, comprising the steps of:

selecting a first value in a table of values based on a first portion of the destination address, each table value having an associated linked list of an integer number of stored entries; comparing the remaining portion of the destination address to the stored entries, if any, in the linked list associated with the selected first value;

forwarding only those messages whose remaining destination address portion does not match a stored entry in the respective linked list;

selecting a second value in the table based on a first portion of the source address;

comparing the remaining portion of the source address to the stored entries, if any, in the linked list associated with the selected second value; and

storing the remaining portion of the source address in the respective linked list if there is no matching entry.

11. The method of claim 10, wherein the destination and source addresses are each six byte MAC addresses and the respective first portions of the destination and source addresses used for selecting the respective first and second table values is the last byte of the respective addresses.

12. The method of claim 10, comprising the further step of:

encapsulating each message to be forwarded into an ATM cell format.

13. The method of claim 10, wherein the first network is an ethernet and the second network is an ATM-based wide area network.

14. The method of claim 10, comprising the further steps of:

monitoring the time period each source address portion is stored in a respective linked list; and

deleting a source address portion from the respective list if an allotted time period has elapsed and no subsequent destination address portion match has occurred.

15. The method of claim 14, comprising the further step of:

renewing the allotted time period that a source address portion is stored in the respective list each time a destination address portion match occurs.

16. A device having means for controlling the transmission of messages from a first network to a second network, the messages each including a destination address and a source addresses, comprising:

memory means for storing a selected portion of the source address of messages received from the first network, wherein the stored portion is linked in the memory to an index value corresponding to a further portion of the respective source address; and

means for comparing selected portions of the destination addresses of messages received from the first

network to those stored source address portions, if any, linked to an index value determined by a further portion of the respective destination address.

17. The device of claim 16, further comprising means for forwarding only those messages whose destination address portion does not match a stored source address portion.

18. The device of claim 17, further comprising means for encapsulating each message to be forwarded into an ATM cell format.

19. The device of claim 16, further comprising:

means for monitoring the time period each source address portion is stored in the memory means;

means for deleting a stored source address portion from the respective memory means if an allotted time period has elapsed and no subsequent destination address portion match has occurred; and

means for renewing the allotted time period that a source address portion is stored in the respective list each time a destination address portion match occurs.

20. A method for selectively forwarding messages from a local area ethernet to an ATM-based wide area network, each message containing respective six byte destination and source MAC addresses, comprising the steps of:

selecting a first value in a table of values based on the last byte the destination address, each table value having an associated linked list of an integer number of stored entries, each stored entry representing

the first five bytes of a MAC address of a device located on the local area ethernet;

comparing the first five bytes of the destination address to the stored entries, if any, in the linked list associated with the selected first value; and

forwarding only those messages in which the first five bytes of the destination address does not match a stored entry in a respective linked list.

21. The method of claim 20, comprising the further steps of:

selecting a second value in the table based on the last byte of the source address;

comparing the first five bytes of the respective source address to the stored entries, if any, in the linked list associated with the selected second value; and

storing the first five bytes of the respective source address in the linked list if there is no matching entry.

AMENDED CLAIMS
[received by the International Bureau on 14 September 1998 (14.09.98); original claims 1-21 replaced by amended claims 1-13 (4 pages)]

1. In a bridge device used for forwarding messages from a first network to a second network, each message including a destination address, an improved method for selectively forwarding only messages whose destination address is not for a device located on the first network, the method comprising the steps of:

selecting a first value in a table of stored values based on a first portion of the destination address, the first table value having an associated linked list containing an integer number of stored entries;

comparing the remaining portion of the destination address to the stored entries, if any, in the linked list; and

forwarding only those messages whose remaining destination address portion does not match a stored entry in the linked list.

2. The method of claim 1, wherein the destination address is a six byte MAC address and the first portion used for selecting the first table value is the last byte of the destination address.

3. The method of claims 1 or 2, comprising the further step of:

encapsulating each message to be forwarded into an ATM cell transmission format.

4. The method of any of the above claims 1-3, each message further including a source address , comprising the further steps of:

selecting a second value in the table based on a first portion of the source address;

comparing the remaining portion of the source address to the stored entries, if any, in the linked list associated with the selected second value; and

storing the remaining portion of the source address in the respective linked list if there is no matching entry.

5. The method of claim 4, comprising the further steps of:

monitoring the time period each source address portion is stored in a respective linked list; and

deleting a source address portion from the respective list if an allotted time period has elapsed and no subsequent destination address portion match has occurred.

6. The method of claim 5, comprising the further step of:

renewing the allotted time period that a source address portion is stored in the respective list each time a destination address portion match occurs.

7. The method of claim 1, wherein the first network is an ethernet and the second network is an ATM-based wide area network.

8. In a bridge device used for forwarding messages from a first network to a second network, each message including a destination address and a source address, an improved method for selectively forwarding only messages, comprising the steps of:

selecting a first value in a table of values based on a first portion of the destination address, each table value having an associated linked list of an integer number of stored entries;

comparing the remaining portion of the destination address to the stored entries, if any, in the linked list associated with the selected first value;

forwarding only those messages whose remaining destination address portion does not match a stored entry in the respective linked list;

selecting a second value in the table based on a first portion of the source address;

comparing the remaining portion of the source address to the stored entries, if any, in the linked list associated with the selected second value; and

storing the remaining portion of the source address in the respective linked list if there is no matching entry.

9. The method of claim 8, comprising the further steps of:

monitoring the time period each source address portion is stored in a respective linked list; and

deleting a source address portion from the respective list if an allotted time period has elapsed and no subsequent destination address portion match has occurred.

10. The method of claim 9, comprising the further step of:

renewing the allotted time period that a source address portion is stored in the respective list each time a destination address portion match occurs.

11. An improved bridge device for controlling the transmission of messages from a first network to a second network, the messages each including a destination address and a source addresses, the improvement comprising:

memory means for storing a selected portion of the source address of messages received from the first network, wherein the stored portion is linked in the memory to an index value corresponding to a further portion of the respective source address; and

means for comparing selected portions of the destination addresses of messages received from the first network to those stored source address portions, if any, linked to an index value determined by a further portion of the respective destination address, and then forwarding only those messages whose destination address portion does not match a stored source address portion.

12. The device of claim 11, further comprising means for encapsulating each message to be forwarded into an ATM cell format.

13. The device of claims 11 or 12, further comprising:

means for monitoring the time period each source address portion is stored in the memory means;

means for deleting a stored source address portion from the respective memory means if an allotted time period has elapsed and no subsequent destination address portion match has occurred; and

means for renewing the allotted time period that a source address portion is stored in the respective list each time a destination address portion match occurs.

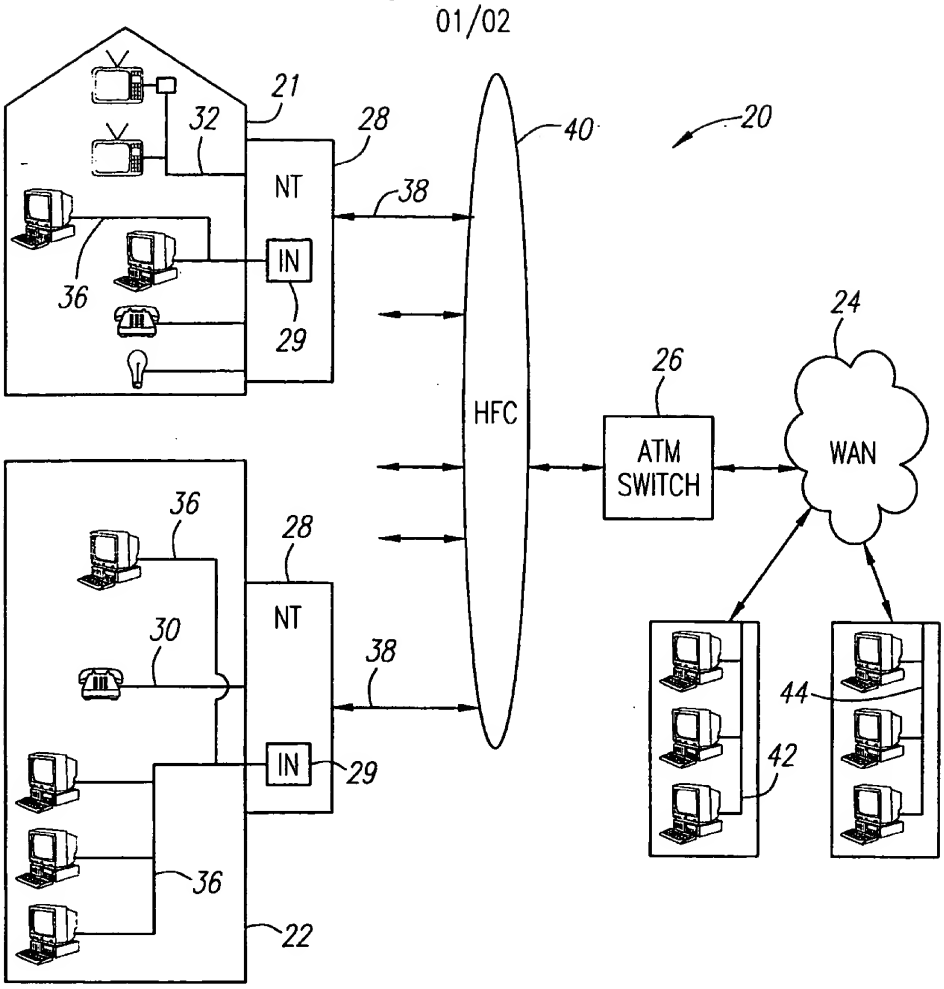
21
32
28
NT
IN
29
36
38
40
20
HFC
24
26
ATM SWITCH
WAN
36
28
NT
30
38
IN
29
36
22
44
42

FIG. 1

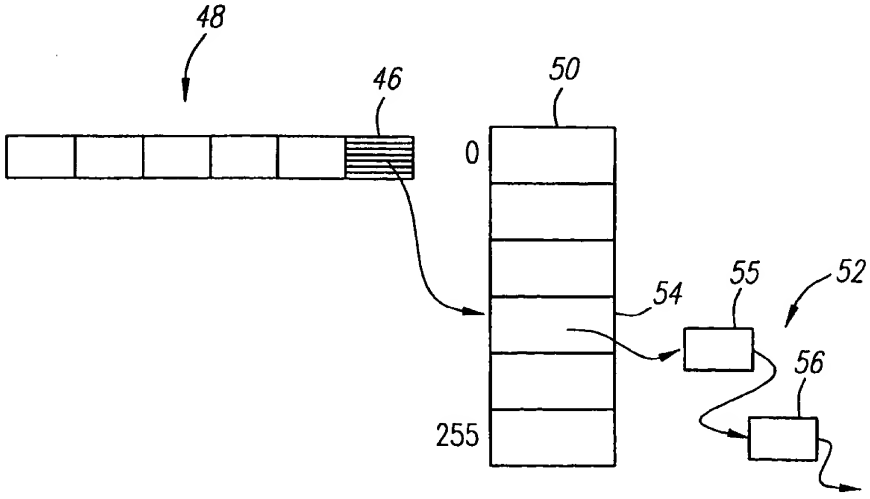
48
46
50
0
255
54
55
52
56

FIG. 2

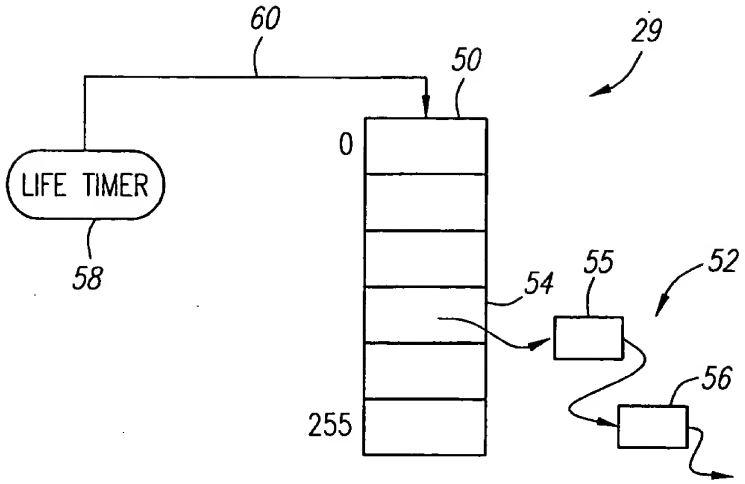
60
29
50
0
LIFE TIMER
58
54
55
52
56
255

FIG. 3

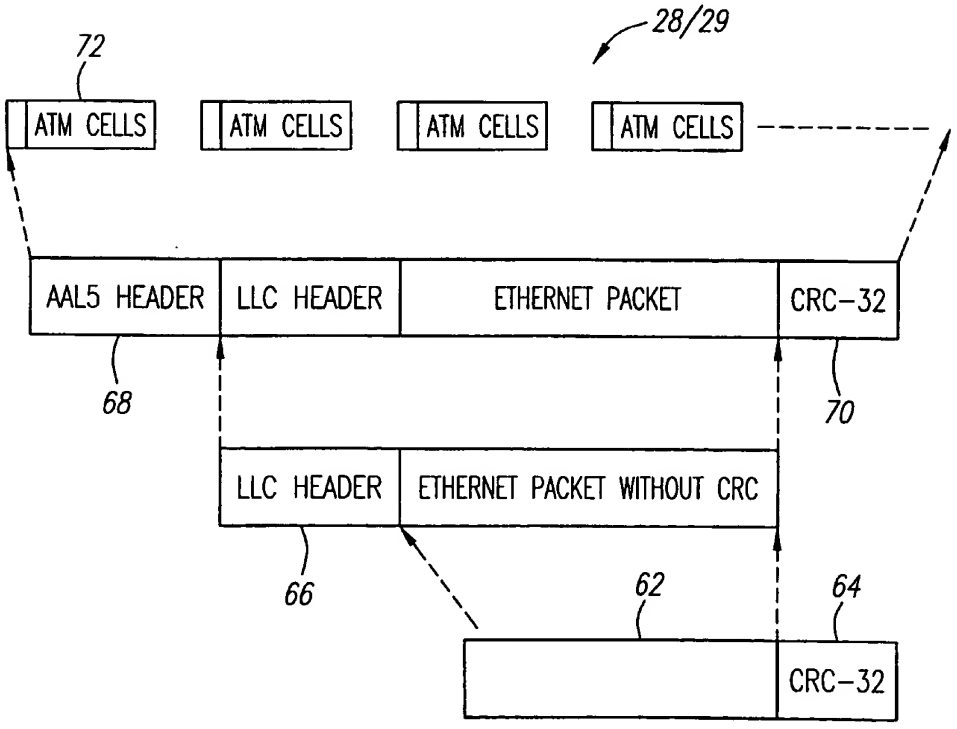
28/29
72
ATM CELLS
ATM CELLS
ATM CELLS
ATM CELLS
AAL5 HEADER
LLC HEADER
ETHERNET PACKET
CRC-32
68
70
LLC HEADER
ETHERNET PACKET WITHOUT CRC
66
62
64
CRC-32

FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/07540

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04Q11/04

According to International Patent Classification(IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04Q H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 5 229 994 A (JEAN-MICHEL BALZANO, PERROS GUIREC, YVON NOSLIER) 20 July 1993 see column 3, line 20 - line 28 see column 4, line 41 - column 5, line 9	1,4,5,9, 16-18,20 6,12,13, 19
X Y	US 5 136 580 A (VIDELOCK GARY B ET AL) 4 August 1992 see column 3, line 20 - line 37 see column 5, line 3 - line 14; figure 2A see claims 1,2	1-4,10, 11,16,17 12,13
Y A	US 5 060 228 A (TSUTSUI EIICHI ET AL) 22 October 1991 see column 2, line 25 - column 3, line 2 see column 3, line 61 - column 4, line 2	6,19 14,15

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 August 1998	17/08/1998

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/07540

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category '	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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2

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

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International Application No
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